Claims

1. A diverter sub with an inlet and outlet each of which is able to be connected to a drill pipe so as to form a continuous conduit, down which mud can be pumped axially, there being a side mud port through which mud can be pumped and a diverter valve mounted within the diverter sub, which diverter valve, in its open position, closes the side mud port and allows mud to be pumped from the inlet down axially through the diverter sub and through the outlet down the drill pipe and which, in its closed position, closes the inlet and opens the side mud port so that mud can be pumped through the side mud port down through the outlet down the drill pipe.

2. A diverter sub as claimed in claim 1 in which there is a sealing means around the side mud port.

3. A diverter sub as claimed in claim 1 comprising (i) a connecting means enabling it to be connected between two drill pipes so that, in use, mud can be pumped axially down through the diverter sub and down the drill pipe, (ii) a side mud port through which mud can be pumped, (iii) a diverter valve mounted within the diverter sub and (iv) a sealing means which seals around the side mud port and in which diverter sub the diverter valve, in its open position, closes the side mud port and allows mud to be pumped axially down through the diverter sub and in its closed position closes the diverter sub and opens the side mud port so that mud can be pumped through the side mud port down through the drill pipe.

4. A diverter sub as claimed in claims 2 or 3 in which the sealing means seals against the exterior of the diverter sub, around or above and below the said mud port, thereby enabling drilling fluid pressure to be applied to the exterior of the mud port.

5. A diverter sub as claimed in any one of claims 2 to 4 in which the sealing means applies mud pressure to the exterior of the mud port by sealing around the mud port or circumferentially around the diverter sub above and below the mud port, and the sealing means is capable of containing mud at full mud pump discharge pressure.

6. A diverter sub as claimed in any one of claims 2 to 5 in which the sealing means is a standard or near standard pipe ram preventer, or a rotary preventer, with a double seal, sealing to the diverter sub, above and below the mud port, such that mud can be introduced into the preventer and enter the mud port between the seals irrespective of the azimuth orientation of the mud port.

7. A diverter sub as claimed in any one of claims 2 to 5 in which the sealing means is a standard or near standard pipe ram preventer, or rotary preventer with a standard or near standard single seal, sealing to the diverter sub, above the mud port, coupled with a second pipe ram preventer or rotary preventer sealing below the mud port, either to the diverter sub, or to the tool joint box at the top of the next tubular in the drill string below it, or to the body of the next tubular in the drill string below it, thus enclosing the space around the mud port, in which high pressure mud can be supplied to the mud port.

8. A diverter sub as claimed in any one of claims 2 to 5 in which the sealing means is a clamp that clamps around the diverter sub and applies a high pressure seal to the area immediately around or above and below the mud port, the said clamp being either in one assembly, through which the drill string passes, or split so that it may be withdrawn substantially from the drillstring without having to disconnect the drill string.

9. A diverter sub as claimed in any one of the preceding claims in which the valve means is passively operated with or without springs, or is actively operated by a mechanical, hydraulic or electrical means.

10. A diverter sub as claimed in any one of the preceding claims in which the internal bore of the diverter sub is the same internal diameter as that of the drill pipe.

11. A diverter sub as claimed in any one of the preceding claims in which the valve means is a ball, plug or other valve.

12. A diverter sub as claimed in any one of the preceding claims in which the diverting valve means is operated by the pressures of the two mud sources, such that, once the mud pressure outside the mud port is raised to that of the tubular to which the diverter sub is connected, only a small drop in the tubular pressure or a small increase in the mud port external pressure will open the mud port and cause mud to flow in through the mud port, and with a further decrease in the pressure of the mud in the tubular, the flow of mud will be entirely from the mud port; the reversal of flow between the diverter sub and the tubular above will cause the diverter sub to shut off this axial flow to the tubular above.

13. A diverter sub as claimed in any one of the preceding claims in which there are two non return valves, one allowing flow downwards from the tubular above and the other allowing flow inwards through the mud port to enable the switching of flows from the tubular above to the mud port to be effected by the related or independent action of the two non return valves.

14. A diverter sub as claimed in any one of claims 2 to 13 in which the sealing means is a mechanical shaft, integrated with the device, to actuate the diverter sub

mechanism, either as a normal procedure or as an override if required, such shaft being capable of manual or machine actuation.

15. A diverter sub as claimed in any one of the preceding claims in which the sealing means is a hydraulic duct plus a plug, socket or seal to apply hydraulic pressure to the diverter sub to effect the mechanical motion required.

16. A diverter sub as claimed in any one of the preceding claims in the diverting valve means is capable of stopping circulation by shutting off both the axial flow and the flow from the mud port, at the same time.

17. A diverter sub as claimed in any one of the preceding claims in which there is a spring to assist in closing off the mud port flow and/or the axial flow.

18. A diverter sub as claimed in any one of the preceding claims in which there is a mechanical connection to allow manual override of the diverter sub mechanism in the event that the diverter sub does not respond adequately to the differential pressures and complete a satisfactory closure of either the mud port flow or the axial flow.

19. A tubular having a diverter sub as claimed in any one of the preceding claims attached to or incorporated at one end of the tubular.

20. A tubular as claimed in claim 19 in which the diverter sub is locked in place so that it cannot inadvertently disconnect.

21. A drill string having a diverter sub as claimed in any one of claims 1 to 18 installed in the drill string with a tool joint connection above and below it, such that the diverter sub includes a box above it and a pin below it.

22. A drill string having a diverter sub as claimed in any one of claims 1 to 18 integrated into the top of a drill pipe joint so that it forms part of the drill pipe tool joint box upset.

23. A drill string assembled with tubulars incorporating a diverter sub as claimed in any one of claims 1 to 18.

24. A drill string as claimed in claim 23 in which the diverter sub is incorporated by integrating the diverter sub into the structure of the drill pipe joint, such that there is no tool joint between the diverter sub and the joint below but the tool joint box of the drill pipe is elongated to accommodate the diverter sub's structure, mechanism and function, between the threaded section of the tool joint box and the shoulder of the upset between the said tool joint box and the body of the drill pipe joint.

25. A method for continuously circulating mud whilst adding a tubular to a drill string which method comprises having a diverter sub mounted on the top of the drill string, which diverter sub has a side mud port and a diverting valve means which, in the open position, opens the diverter sub and closes the side mud port and, in the closed position, opens the side mud port and closes the diverter sub, in which method the diverting valve means is switched to the closed position, mud is circulated through the side mud port and down the drill string, a tubular is connected to the top of the diverter sub and the diverting valve means is switched to its open position and mud is circulated axially through the added tubular and diverter sub and down through the drill string.

26. A method as claimed in claim 25 in which there is a sealing means around the side mud port which seals against the exterior of the diverter sub, around or above and below the said mud port and thereby applies drilling fluid pressure to the exterior of the mud port.

27. A method for drilling wells, in which a drill bit is rotated at the end of a drill string comprising tubular members joined together and drilling fluid (mud) is circulated through the tubular string, in which method tubular members are added to or removed from the drill string whilst circulation of mud continues, in which method a diverter sub is added to the top of a joint or stand of drill pipe, the said sub having a mud port in its side through which mud can be supplied at full mud pump pressure to contribute part or all of the circulation of mud down the drill string, the diverter sub having the ability to close off the axial flow of mud flowing downwards from the tubular above or the axial flow of mud flowing upwards to the tubular above.

28. A method as claimed in any one of claims 25 to 27 in which the flow of mud is from the tubular above the diverter sub, the mud port is opened to allow mud to also flow in from the mud port and to mix with the mud flowing down the drill string from the tubular above.

29. A method as claimed in any one of claims 25 to 28 in which the diverter sub shuts off the flow of mud from the tubular above and allows the mud flow down the drill string to emanate substantially from the mud port.

30. A method as claimed in any one of claims 25 to 29 in which the valve means is passively operated with or without springs, or is actively operated by a mechanical, hydraulic or electrical means.

31. A method as claimed in any one of claims 25 to 30 in which the internal bore of the diverter sub is substantially the same internal diameter as that of the drill pipe.

32. A method as claimed in any one of claims 25 to 31 in which the diverting valve means is operated by the pressures of the two mud sources, such that, once the mud pressure outside the mud port is raised to that of the tubular to which the diverter sub is connected, a small drop in the tubular pressure or a small increase in the mud port external pressure will open the mud port and cause mud to flow in through the mud port, and with a further decrease in the pressure of the mud in the tubular, the flow of mud is entirely from the mud port, the reversal of flow between the diverter sub and the tubular above causing the diverter sub to shut off this axial flow to the tubular above.

33. A method as claimed in any one of claims 25 to 32 in which there are two non return valves, one allowing flow downwards from the tubular above and the other allowing flow inwards through the mud port to enable the switching of flows from the tubular above to the mud port to be effected by the related or independent action of the two non return valves.

34. A method as claimed in any one of claims 25 to 33 in which the sealing means is a mechanical shaft, integrated with the device, to actuate the diverter sub mechanism, either as a normal procedure or as an override if required, such shaft being capable of manual or machine actuation.

35. A method as claimed in any one of claims 25 to 34 in which the sealing means is a hydraulic duct plus a plug, socket or seal to apply hydraulic pressure to the diverter sub to effect the mechanical motion required.

36. A method as claimed in any one of claims 25 to 35 in which the diverter sub is capable of stopping circulation by shutting off both the axial flow and the flow from the mud port, at the same time.

37. A method as claimed in any one of claims 25 to 36 in which there is a mechanical connection to allow manual override of the diverter sub mechanism in the event that the diverter sub does not respond adequately to the differential pressures and complete a satisfactory closure of either the mud port flow or the axial flow.

38. A method for drilling wells as claimed in any one of claims 25 to 37, in which a drill bit is rotated at the end of a drill string, the drill string being as claimed in any one of claims 21 to 24 and in which drilling fluid (mud) is circulated through the drill string, and a tubular is added by closing the diverting valve means to close off the axial flow of drilling fluid down the diverter and pumping mud through the mud port down the drill string, adding a tubular to the top of the diverter sub and closing the mud port so mud is pumped through the added tubular axially through the diverter and down the drill string.

39. A method of adding or removing a tubular to a drill string with continuous circulation of drilling mud and/or continuous rotation of the drill string in which the end of the tubulars which are to be connected or disconnected are not enclosed in a chamber as they come apart or are connected and/or without having to snub the tubular towards the drill string to achieve closure and/or without having to have any gears or grips or mechanical parts operating in drilling fluids such as mud and/or without having to have special thread lubricants to avoid wash-off by turbulent mud.

40. A method of adding or removing tubulars to a drill string in which there is continuous circulation of drilling mud without the need for an enclosure around the end of the tubulars which are to be added or removed, without snubbing against mud pressure, without immersing mechanisms in the mud and without using special thread lubricants.

41. A method as claimed in claims 39 or 40 in which the tubulars are connected and disconnected using the method of any one of claims 25 to 38.

42. A method as claimed in any one of claims 25 to 41 in which the tubulars are added or removed during rotation of the drill string.

43. A valve which comprises a first inlet and a second inlet and an outlet in which a valve in a first position opens the first inlet and closes the second inlet and, in a second position closes the first inlet and opens the second inlet.

44. A valve as claimed in claim 43 in which, when the valve switches from the first position to the second position, for at least part of the said switch, both the first and second inlet are open so flow of fluid from the first and second inlet overlap.

45. A valve as claimed in claims 43 or 44 in which the curved surface forms the blade of the valve.

46. A valve as claimed in claim 45 in which the said surface is formed substantially entirely from a section of cylinder, which ensures that, in the open position, this valve blade takes up the minimum possible wall thickness.

47. A valve as claimed in any one of claims 44 to 46 in which the shape of the sealing surface of the blade in the closed position, approximates to sections of two ellipses which, when the valve is closed, seal against a ledge in the conduit.

48. A valve as claimed in any one of claims 43 to 47 in which the valve blade moves between the open and closed positions and the valve is assisted in at least part of its opening and closing by the action of a spring or springs.

49. A valve as claimed in any one of claims 43 to 48 in which there are seals on the sealing surface of the valve blade which are capable of withstanding a pressure differential of up to 5,000psi or more.

50. A diverter sub as claimed in any one of claims 1 to 18 in which the said diverter valve is a valve as claimed in any one of claims 43 to 49.

51. A diverter sub as claimed in claim 50 in which the valve blade, when open, conforms to a section of the cylindrical wall of the diverter sub and has a sealing edge, when closed, that matches a sealing surface cut into the internal cylindrical wall of the diverter sub, the valve blade moving through some 30^0 to 90^0 between open and closed positions.

52. A diverter sub as claimed in claim 51 in which the sealing edge, when closed, matches a sealing surface cut into the internal cylindrical wall of the diverter sub, up to its hinge, which consists of a slice of ball valve, requiring no more wall thickness than the thickness of the valve blade, with the valve blade and ball valve slice moving through less than 90^0 between open and closed positions.

53. A diverter sub as claimed in claimed in claims 50 to 52 in which the diverter valve is actuated and/or locked by externally applied mechanical, hydraulic or electrical means, for example by a rotating slidable cylindrical collar around the diverter sub, or by hydraulic pressure applied to the exterior of the diverter sub or by a strong magnetic field around the diverter sub.

54. A tubular as claimed in claims 19 or 20 in which the diverter sub is as claimed in any one of claims 50 to 53.

55. A drill string as claimed in any one of claims 21 to 24 in which the diverter sub is as claimed in any one of claims 50 to 53.